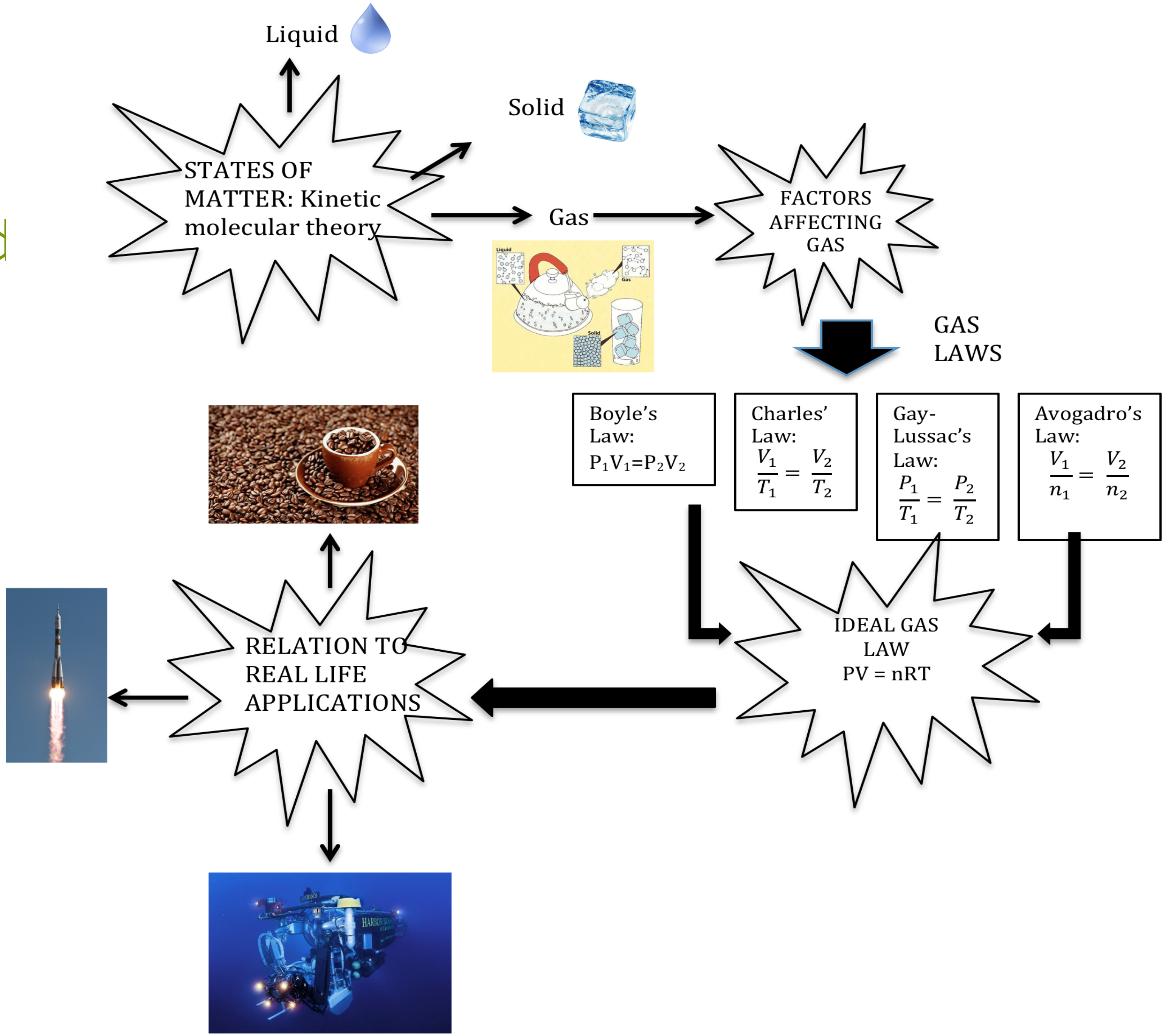
Gases and Atmospheric Chemistry

SCH3U

Lesson #1

- Review of states of matter
- Introduction to Kinetic molecular theory postulates
- KMT outside
- Debrief

Unit Mind Map Overview



Why Study Gases?

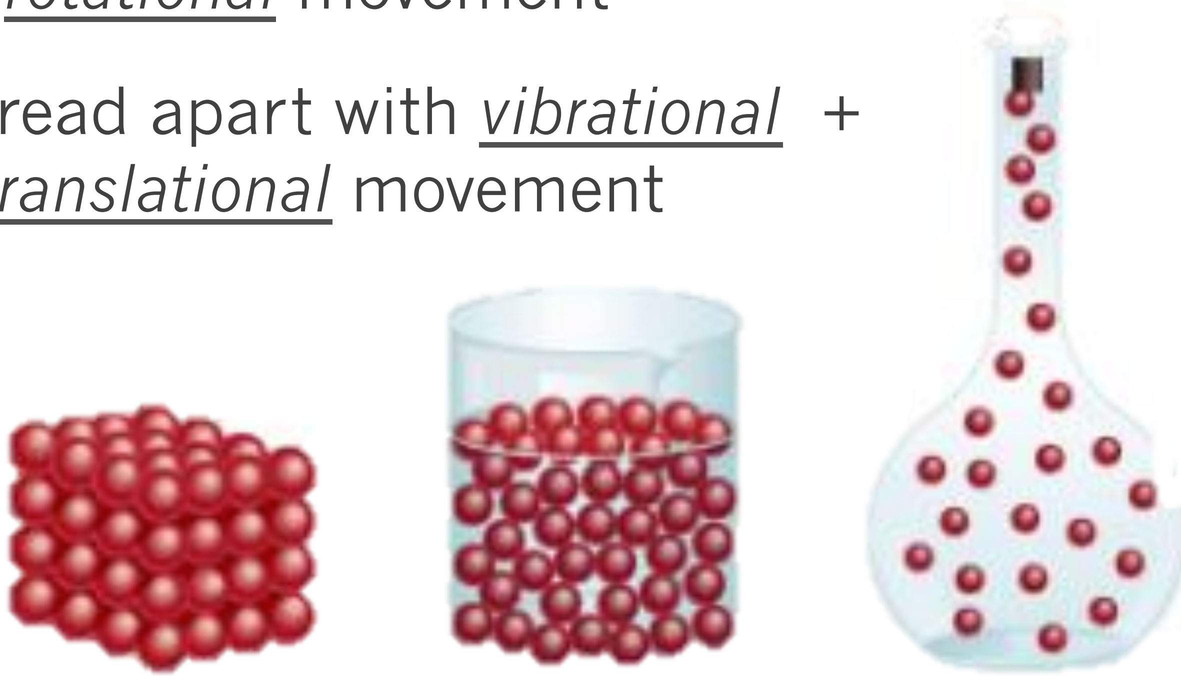
Why Study Gases?

- Everyday life:
  - Medical technologies e.g. anesthetics
  - Food industry e.g. gas in coke can
  - Compose our atmosphere e.g. breathe oxygen and study of climate change
  - Activities e.g. scuba diving, hot air balloons
  - Pleasure e.g. air conditioning (compressed air that expands and gets cold)

States of Matter

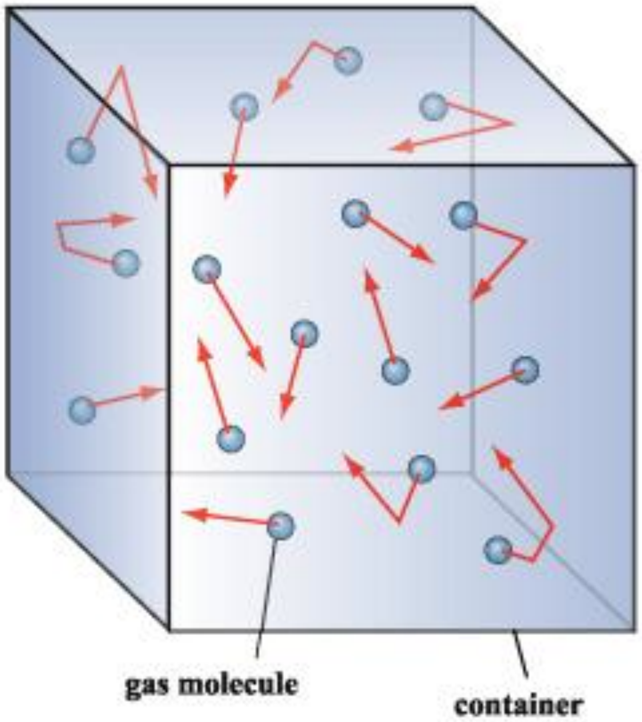
States of Matter

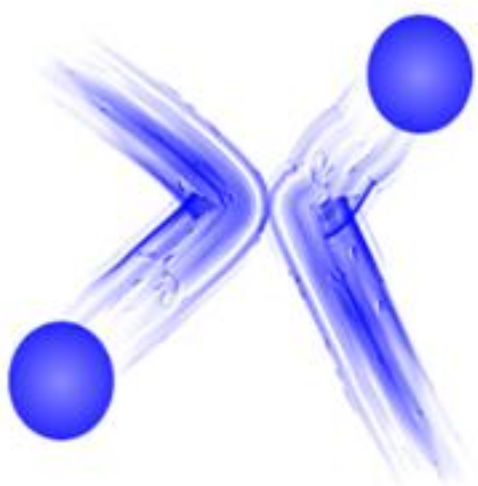
- **Solid**: tightly packed together and *vibrational* movement
- **Liquid**: more loosely packed together but *vibrational* + *rotational* movement
- **Gas**: very spread apart with *vibrational* + *rotational* + *translational* movement



Kinetic Molecular Theory

- A series of postulates that help explain how gases work (their properties, mechanisms and interactions) on a micro scale





Kinetic Molecular Theory

- *Gases consist of large numbers of tiny particles that are far apart relative to their own size.*
- *There are no forces of attraction or repulsion between gas particles.*
- *Gas particles move continuously, rapidly, and randomly in straight lines in all directions.*
- *All collisions between particles and each other or the container are considered to be elastic collisions (no loss of kinetic energy)*
- *The average kinetic energy depends on the temperature of the gas (directly increases with temperature increase)*

Human Kinetics!

Rules:

1. Think of yourself as a small particle within a gas and the room is a Tupperware container that we are all in
2. Behave as the particle would according to the postulate being read
3. DO NOT loose kinetic energy, so no falling down or pushing each other around
4. Those who do not wish to participate can observe or act as a wall of the container
5. Any time you (as a particle) come in contact with another particle you must touch ping pong balls

Lesson #2

- Introduction to Boyle's law
- Practice problems
- Introduction to Charles' Law
- Practice problems
- GIZMO assignment

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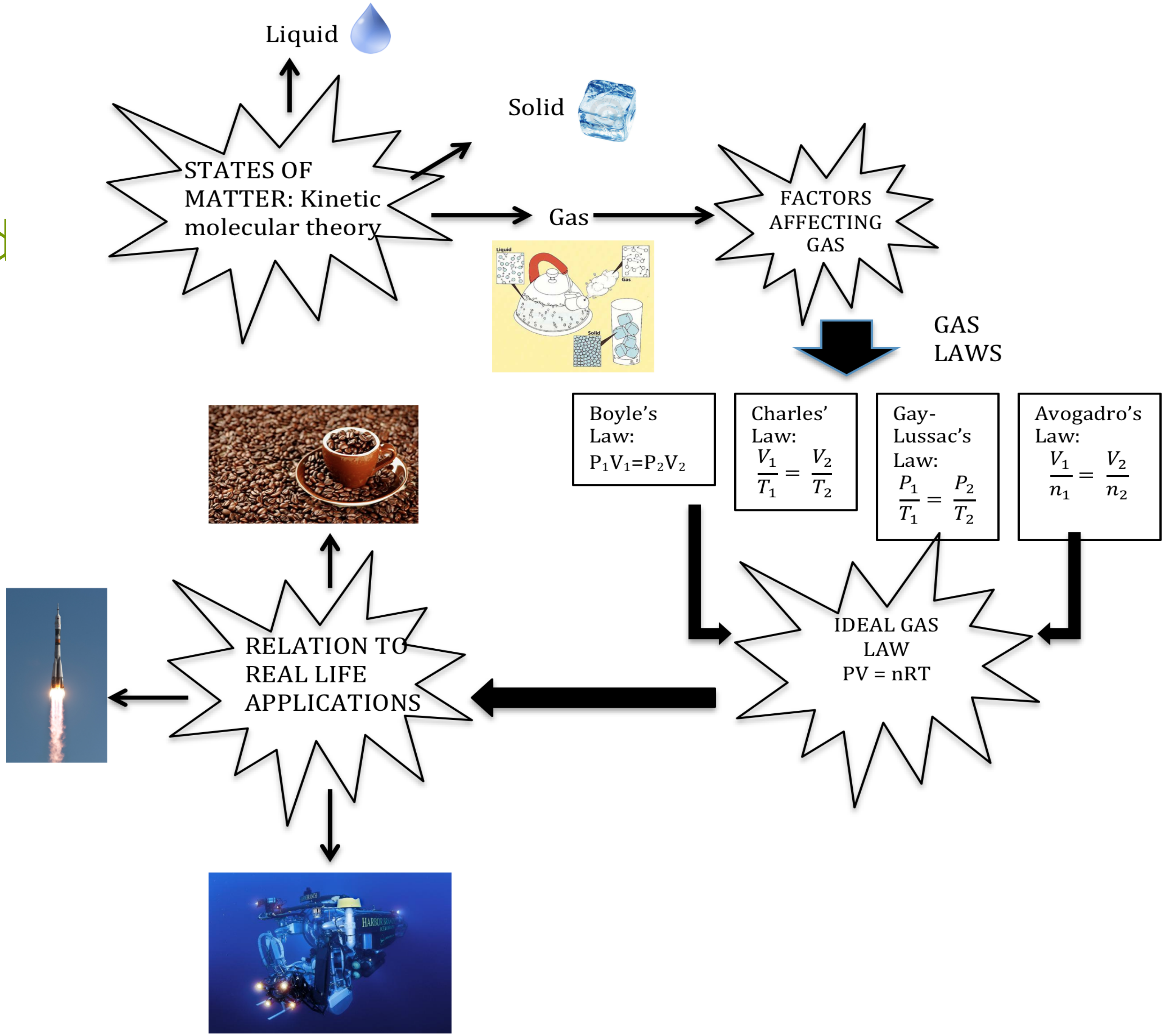

Gas laws

- Boyle's Law
- Charles' Law
- Gay-Lussac's Law
- Dalton's law of partial pressures
- Avogadro's Law
- Ideal gas law

Gas laws

- **Boyle's Law**
- Charles' Law
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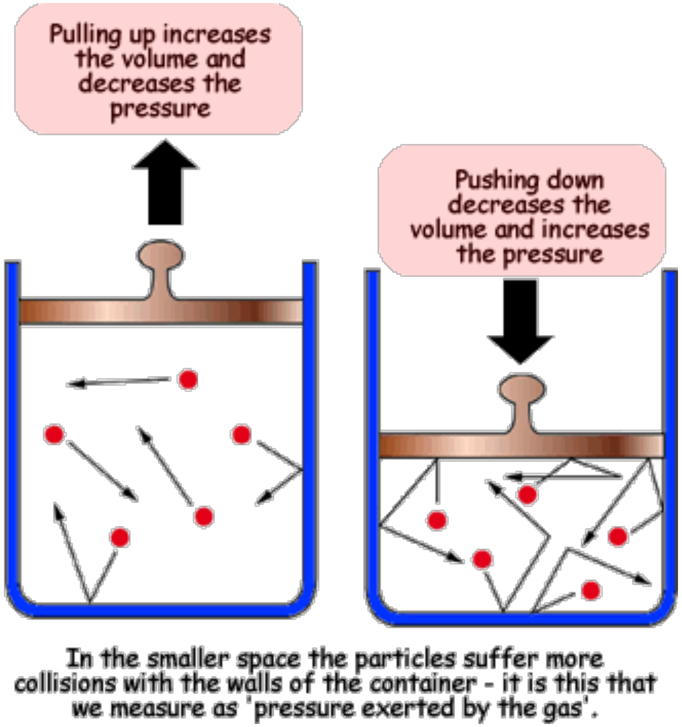
Boyle's laws

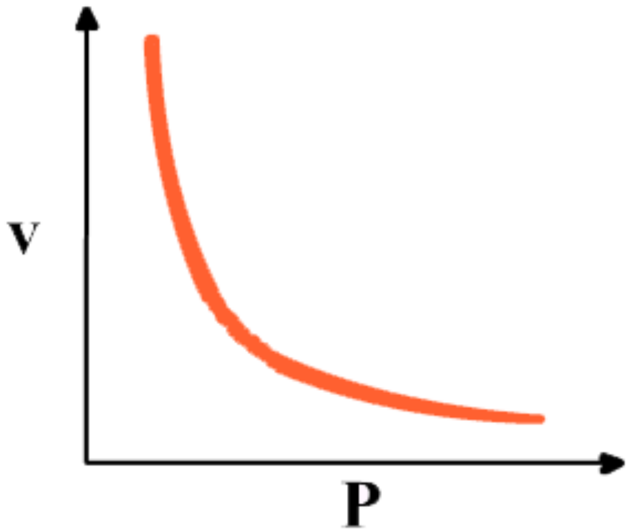
- Relationship between volume and pressure
- What is this relationship?

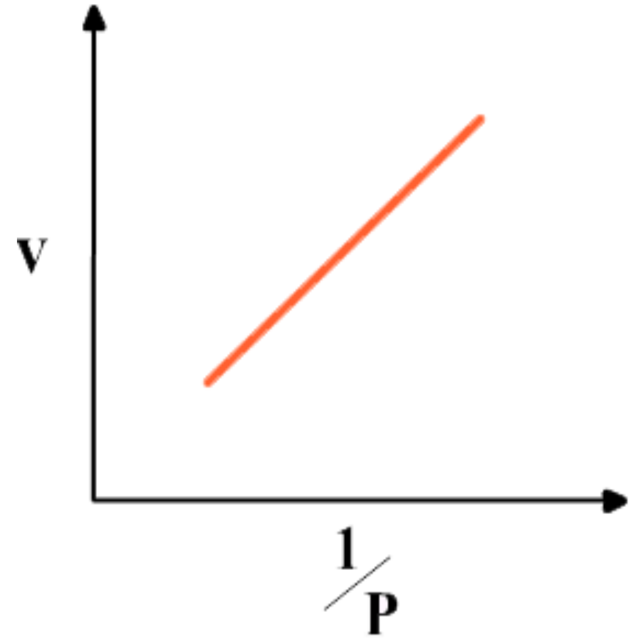
Boyle's Law

- http://www.youtube.com/watch?v=XoytjcUmR90
- Robert Boyle (1662)
- **Boyle's Law** – As the volume of a gas increases, the pressure decreases as long as the temperature and amount of gas remain constant
- $P_1V_1=P_2V_2$



Boyle's Law

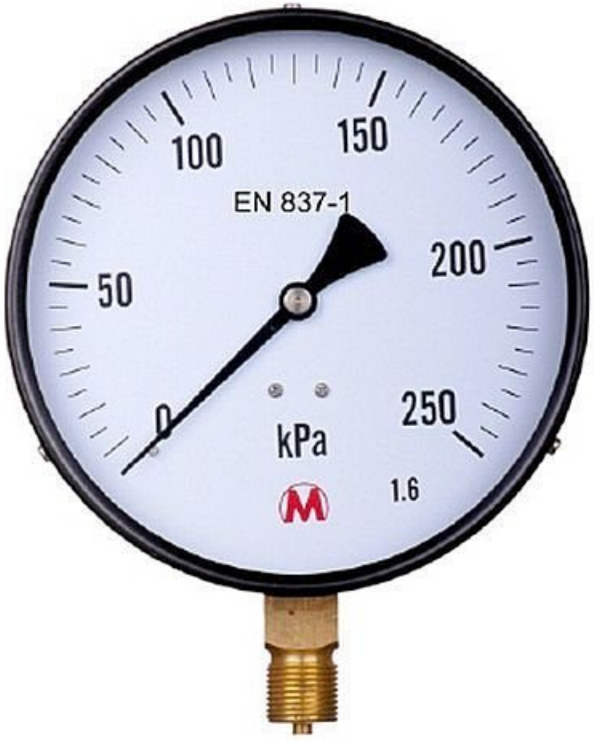




- Slope of the line = k
- $P_i \times V_i = k$
- $P_f \times V_f = k$
- $P_i V_i = P_f V_f$

Pressure

- **Pressure** →what is it?



Pressure

- **Pressure** → force exerted on an object per unit of surface area:

  (Pressure =Force/Surface Area)

  ($P = F/A$)
- **Units of pressure** → Kilopascals (kPa)
- **Standard atmospheric pressure at 0°C:**

  760mm Hg = 760 torr = 1atm = 101.3kPa

- STP (standard temperature and pressure)
  - 0°C, 1atm
- How does a gas exert pressure?

Sample problem using Boyle's law

- Ammonia gas occupies a volume of 450mL at a pressure of 720mmHg. What volume will it occupy at standard pressure?

*Boyle's Law = $P_1V_1 = P_2V_2$

- Complete p. 435 **practice problems** #3,4
- **Homework: p.435 section review # 4, 5, 6**

Gas laws

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Charles' Law

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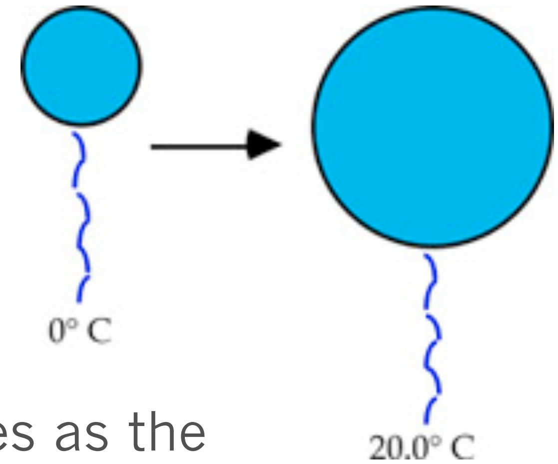
- What is this relationship?

Charles' Law

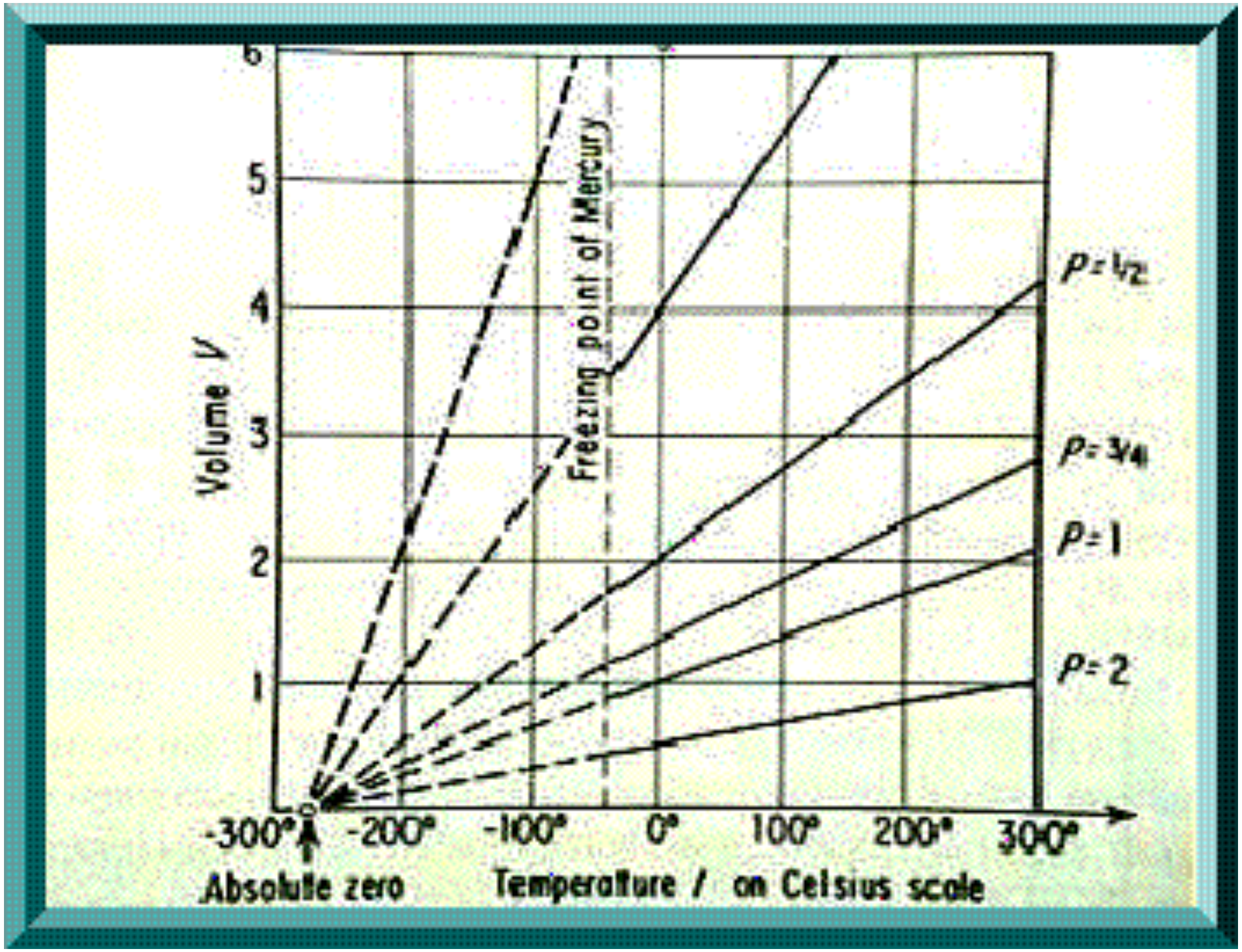


- http://www.youtube.com/watch?v=iSK5YIsMv4c&feature=related
- Jaques Charles
- **Charles' law** → the volume of a gas increases as the temperature increases as long as the mass and the pressure of the gas remain constant
- $V_1/T_1 = V_2/T_2$
- Lungs cannot expand as much when it is cold
- Other examples?

Kelvin Scale and Absolute Zero

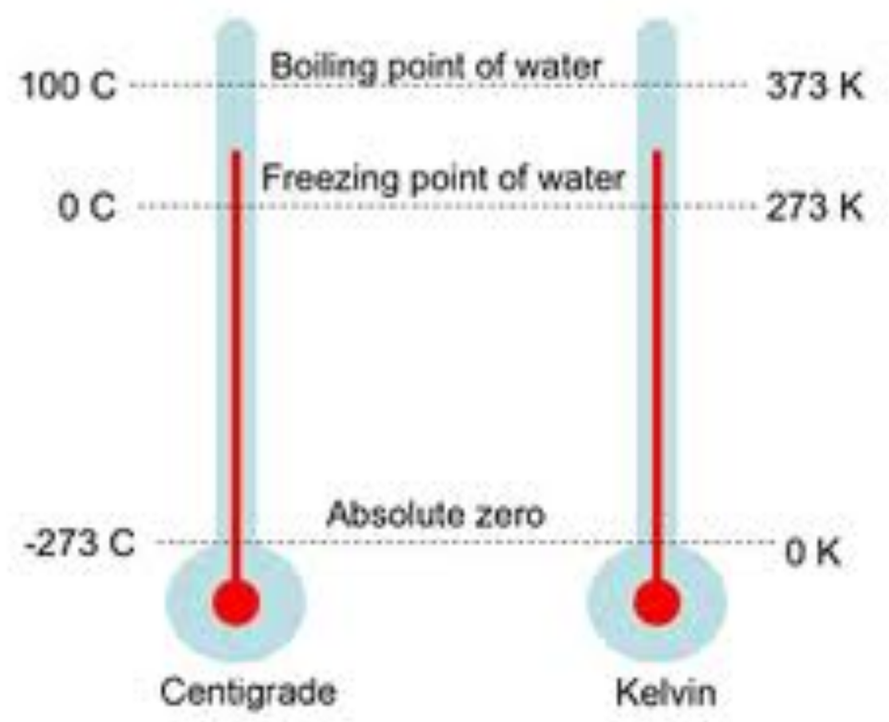
Kelvin Scale and Absolute Zero

- Lord Kelvin discovered that no matter what gas was tested, the temperature of any gas at a volume of 0 was always -273°C



Kelvin Scale and Absolute Zero

- Molecular motion ceases at -273°C/0K
- New scale, where the starting point was zero (0K = -273°C)
- Standard temperature = 273K
- Must convert to K when solving:
  - T_K = °C + 273



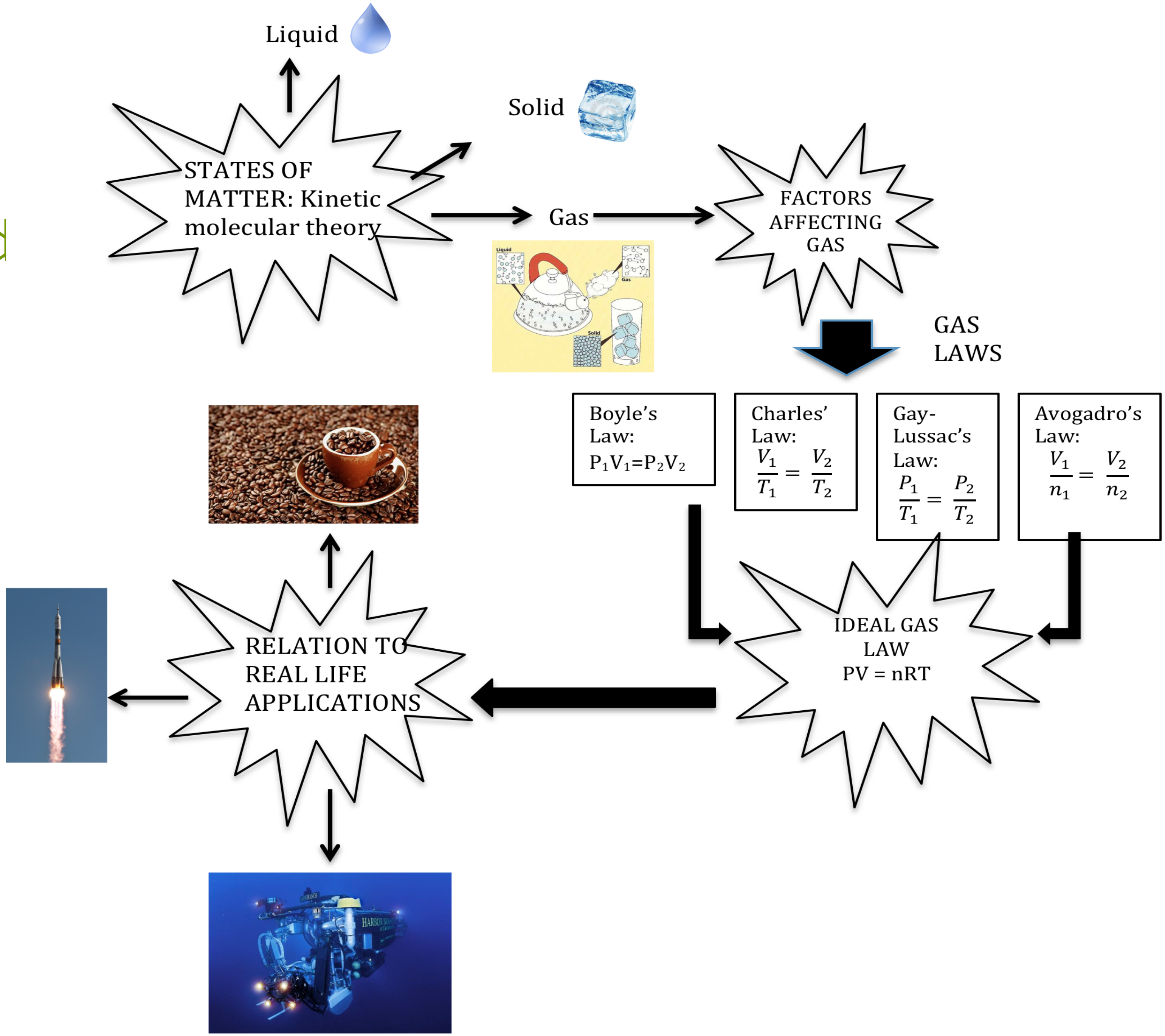
Sample Problems

- Convert:
  - A) 52°C to Kelvin
  - B) 338K to °C
- A sample of argon gas is cooled and its volume went from 380mL to 250mL. If its final temperature was -55°C, what was its original temperature?
- Complete P. 446 **practice problems** #5
- **Homework P. 446 practice problems #6, 8, 11, 12**

Lesson #3

- Gay Lussac's Law
- Dalton's law
- Coke bottle activity/GIZMO

Unit Mind Map Overview



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Gay-Lussac's Law

- Most containers have a fixed volume but the temperature and pressure may vary
- Relationship?

Gay-Lussac's Law

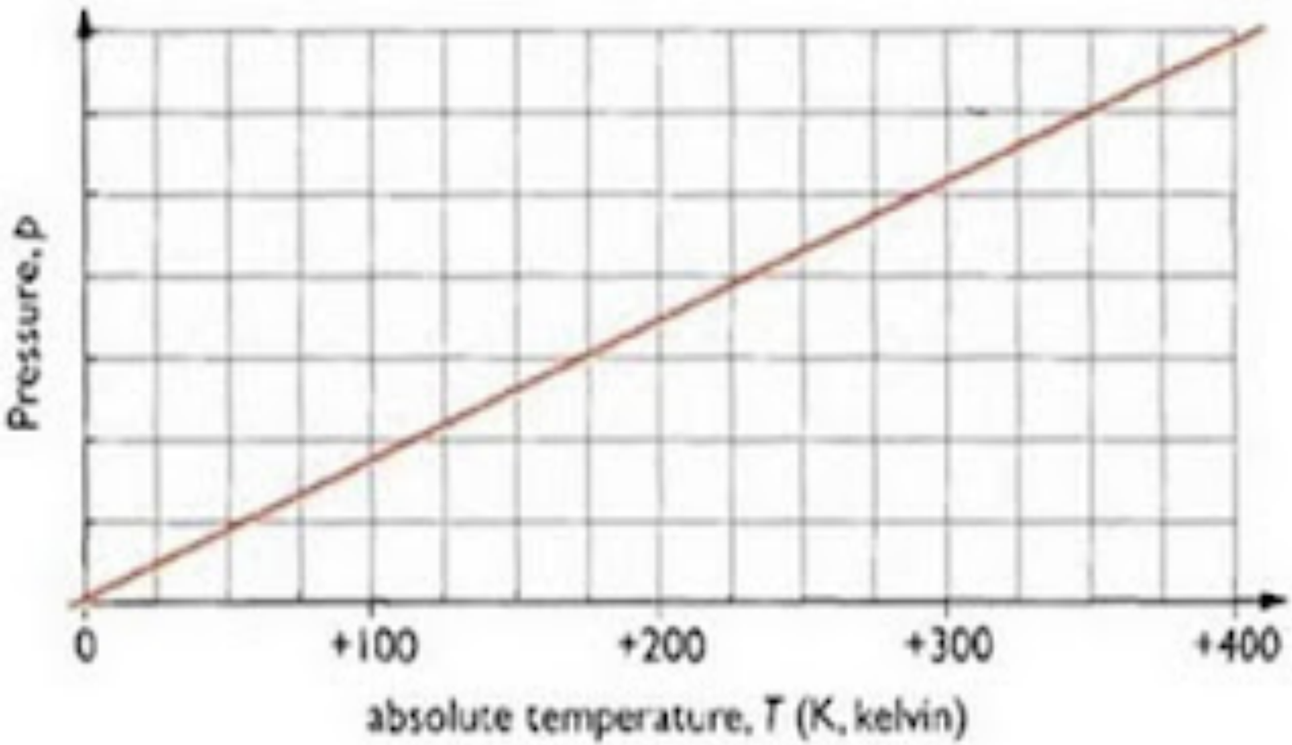
- **Gay-Lussac's Law →** The pressure of a gas increases proportionally to the temperature as long as the volume remains constant
- $(P_i/T_i) = (P_f/T_f)$
- KMT →

Gay-Lussac's Law

- **Gay-Lussac's Law** → The pressure or a gas increases proportionally to the temperature as long as the volume remains constant
- **$(P_i/T_i) = (P_f/T_f)$**
- KMT: temperature increases → kinetic energy of molecules increase → colliding with walls more often → therefore pressure increases

Gay-Lussac's Law

- $P_1/T_1 = 180kPa/100K = 1.8kPa/K$
- $P_2/T_2 = 360kPa/200K = 1.8kPa/K$
- $(P_1/T_1) = (P_2/T_2)$

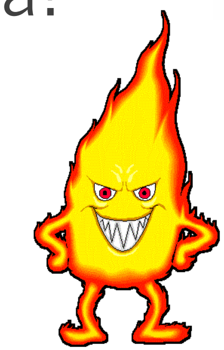


Examples of Gay-Lussac's Law

Examples of Gay-Lussac's Law

- Car tires in winter/summer?

- Heating up a bottle of soda?



- Why do aerosol cans have flammable sign?

Sample Problems

- A sample of gas is stored in a reinforced steel container at -115°C, at a pressure of 39.9kPa. If the pressure was increased to 60kPa, what is the final Celsius temperature?

Sample Problems

- A sample of gas is stored in a reinforced steel container at -115°C, at a pressure of 39.9kPa. If the pressure was increased to 60kPa, what is the final Celsius temperature?
  - **ANSWER: T_2 = 241K, T_2 = -32°C**

Sample Problems

- Soccer balls are typically inflated between 60 and 110kPa. A soccer ball is inflated indoors with a pressure of 85kPa at 25°C. If it is taken outside, where the temperature on the playing field is -11.4°C, what is the pressure of the gas inside the soccer ball?

Sample Problems

- Soccer balls are typically inflated between 60 and 110kPa. A soccer ball is inflated indoors with a pressure of 85kPa at 25°C. If it is taken outside, where the temperature on the playing field is -11.4°C, what is the pressure of the gas inside the soccer ball?
  - **Answer: 96.6 kPa**

HOMEWORK: p. 450 #14, 15 p. 451 #2, 3, 4, 5

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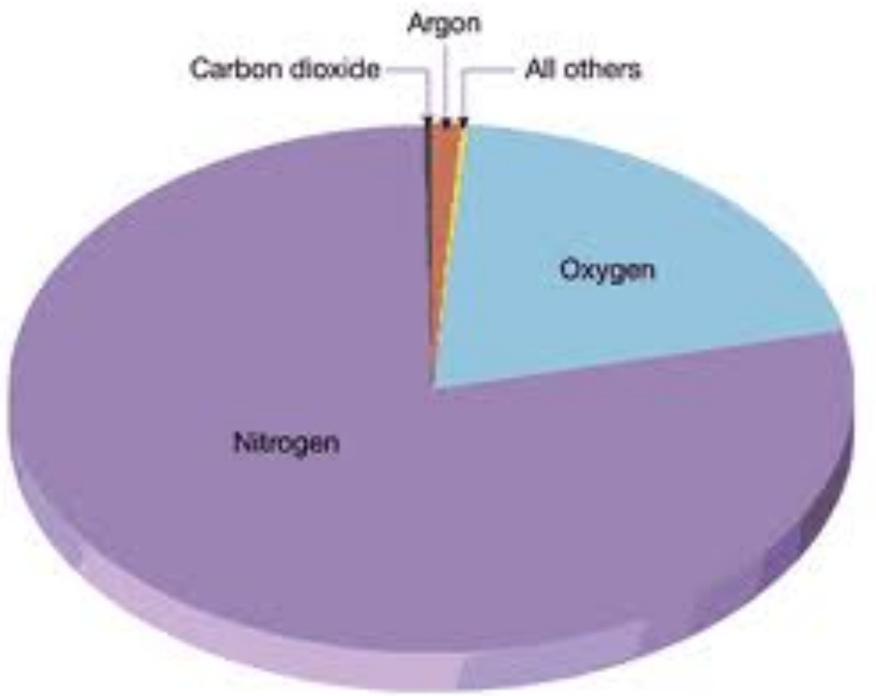
The Atmosphere

- Gases in the atmosphere?

The Atmosphere

- The atmosphere → consists of many gases, what are they?
  - 78.08% Nitrogen
  - 20.95% Oxygen
  - 0.93% Argon
  - 0.03% Carbon Dioxide
  - 0.002% Neon
  - 0.008% other gases



Mixture of Gases

Mixture of Gases

- The atmosphere – air
- Volcanic eruptions → expansion of a mixture of gases
- Anesthesiology
- Natural gas → mixture of hydrocarbon gases

Dalton's Law of Partial Pressures

- Partial pressures → force exerted by one gas in a mixture of gases
- **Law of partial pressures** → the total pressure of a mixture of non-reacting gases is equal to the sum of partial pressures of the individual gases
- $\mathbf{P_{total} = P_1 + P_2 + P_3 + P_4 \ldots}$
- Kinetic Molecular Theory?

Sample Problem

- The pressure of a mixture of nitrogen, carbon dioxide, and oxygen is 150 kPa. What is the partial pressure of oxygen if the partial pressures of the nitrogen and carbon dioxide are 100 kPA and 24 kPa, respectively?

Sample Problem

- The pressure of a mixture of nitrogen, carbon dioxide, and oxygen is 150 kPa. What is the partial pressure of oxygen if the partial pressures of the nitrogen and carbon dioxide are 100 kPA and 24 kPa, respectively?
- **Answer: 26kPa**

Sample Problem

- What is the pressure contribution of Nitrogen on a very dry day when the barometer read 0.98atm?

Components	Percentage
Nitrogen	79%
Oxygen	21%
Argon	1%
Carbon Dioxide	0.03%
Other gases	0.008%

Sample Problem

- What is the pressure contribution of Nitrogen on a very dry day when the barometer read 0.98atm?
- **Solution:**

$$\frac{\%N_2}{100} \times \text{Total Atmospheric pressure}$$

= (79%/100) x 0.98atm

= 0.77atm

Components	Percentage
Nitrogen	79%
Oxygen	21%
Argon	1%
Carbon Dioxide	0.03%
Other gases	0.008%

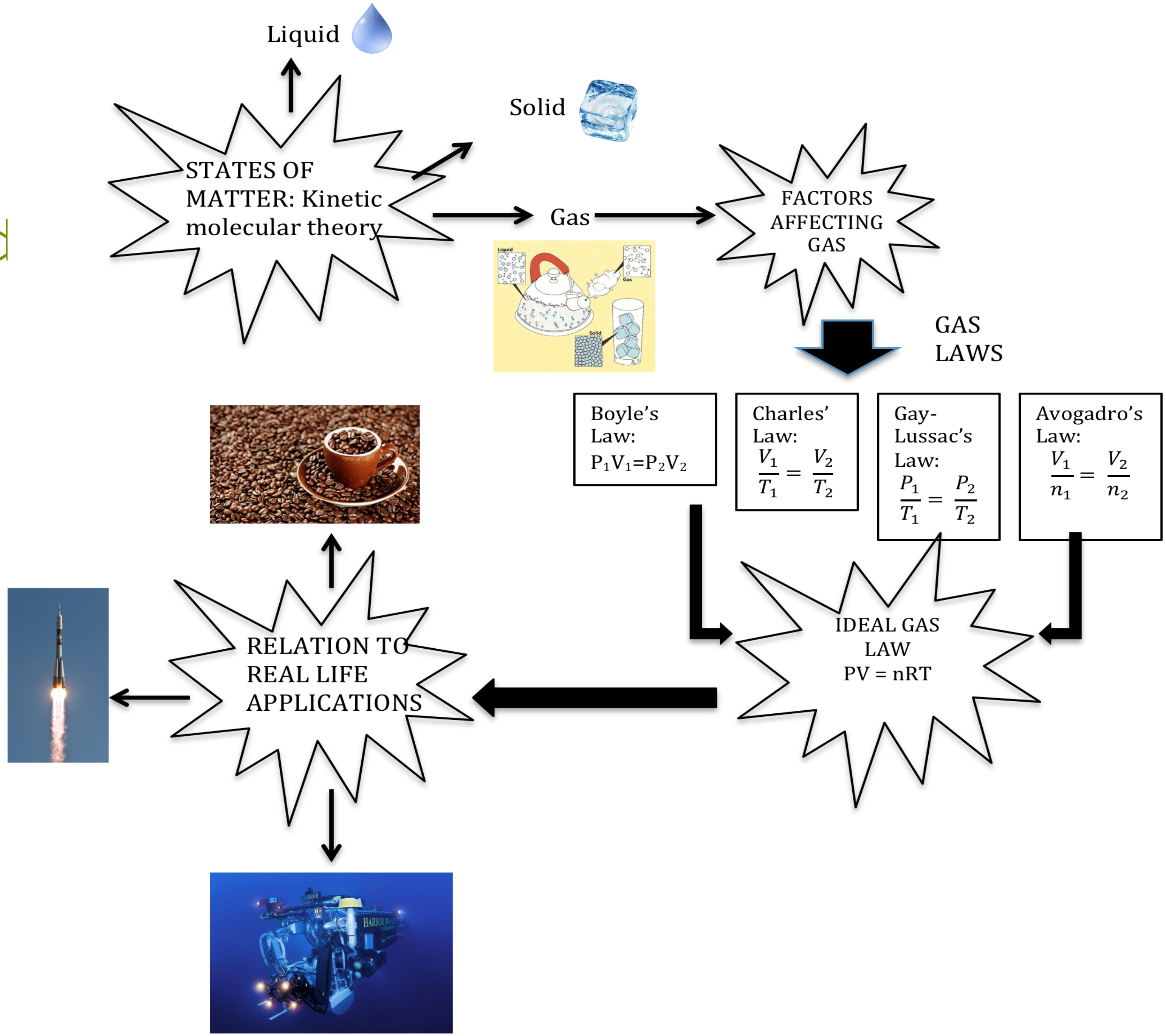
Sample Problem

- HOMEWORK: #22, 23, 24

Lesson #4

- Avogadro's principle
- Ideal gas law
- Coke bottle activity/GIZMO

Unit Mind Map Overview



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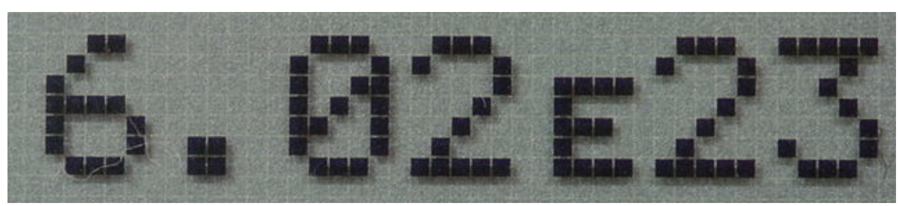
Avogadro

- What do you think of when you hear "Avogadro"?

Avogadro

- What do you think of when you hear "Avogadro"?



Avogadro's Law

- **Avogadro's Law:** *equal* volumes of gases at the same temperature and pressure contain *equal* number of moles

Avogadro's Law

- **Avogadro's Law:** *equal* volumes of gases at the same temperature and pressure contain *equal* number of moles
- $$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Sample problem

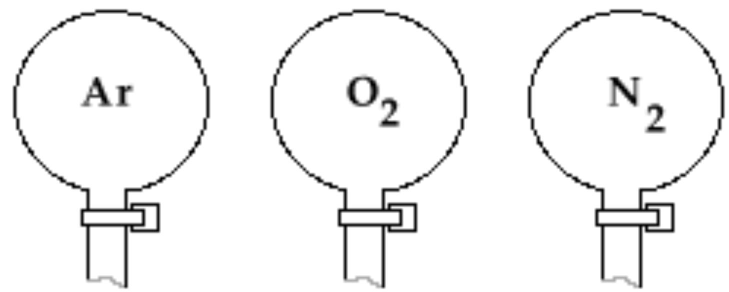
- A balloon with a volume of 34.5L is filled with 3.2mol of helium gas. To what volume will the balloon expand if another 8.0g of helium is added? (Assume that pressure and temperature do not change)

Sample problem

- A balloon with a volume of 34.5L is filled with 3.2mol of helium gas. To what volume will the balloon expand if another 8.0g of helium is added? (Assume that pressure and temperature do not change)
- **ANSWER: 20.9L**

Molar Volume

- **Molar volume:** the volume that 1 mol of ANY GAS occupies at STP (273K, 1atm)
- Molar volume = 22.4L/mol
- Note whether the conditions are in STP



Volume:	22.4 L	22.4 L	22.4 L
Mass:	40 g	32 g	28 g
Quantity:	1 mol	1 mol	1 mol
Pressure:	1 atm	1 atm	1 atm
Temperature:	273 K	273 K	273 K

Sample problem

- You are at a farm in the country side collecting samples of methane from cows. At **STP**, how many moles of are found in 2.5L of methane (CH_4)?

Sample problem

- You are at a farm in the country side collecting samples of methane from cows. At **STP**, how many moles of are found in 2.5L of methane (CH_4)?
- **ANSWER: 0.11mol**

Sample problem

- Calculate the volume that 4.5kg of ethylene gas (C_2H_4) will occupy at **STP.**

Sample problem

- Calculate the volume that 4.5kg of ethylene gas (C_2H_4) will occupy at **STP.**
- **ANSWER: 3,548L**

HOMEWORK: Practice problems p. 477 #1- 4

Practice problems p. 482 # 5, 8, 9

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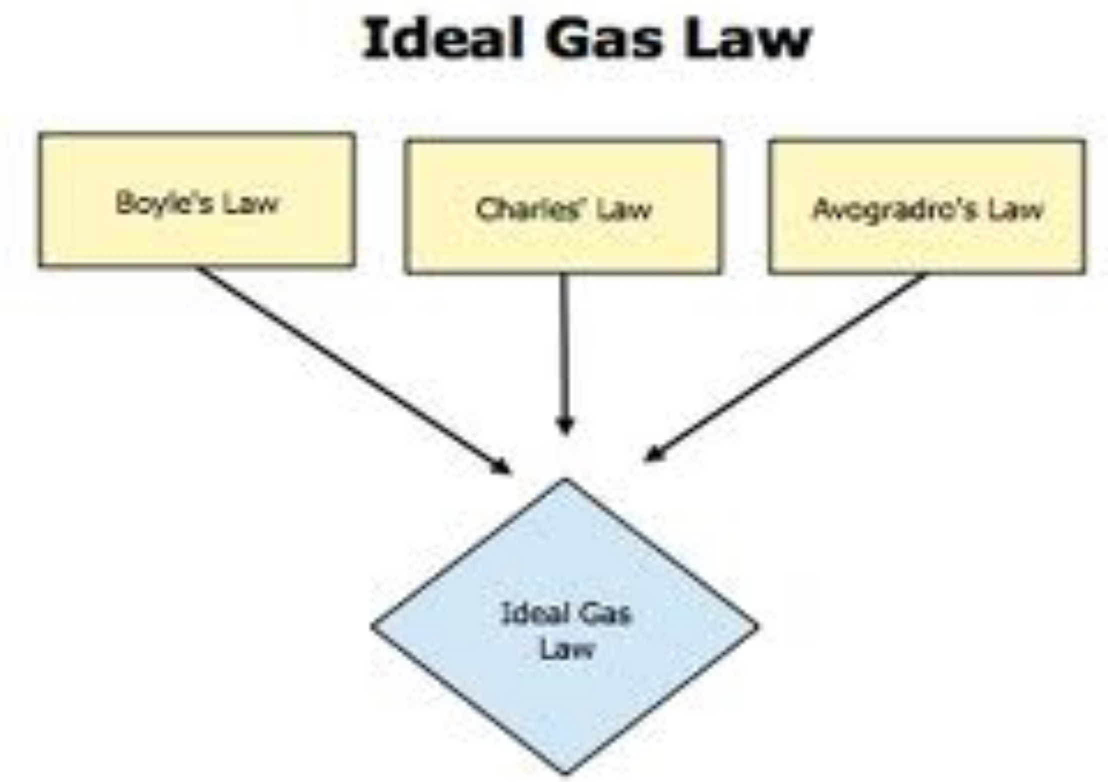
- **Ideal gas law**

Ideal Gas Law

Ideal Gas Law

- Kinetic molecular theory explains what an "ideal gas" is
- "Ideal" versus "Real" gas

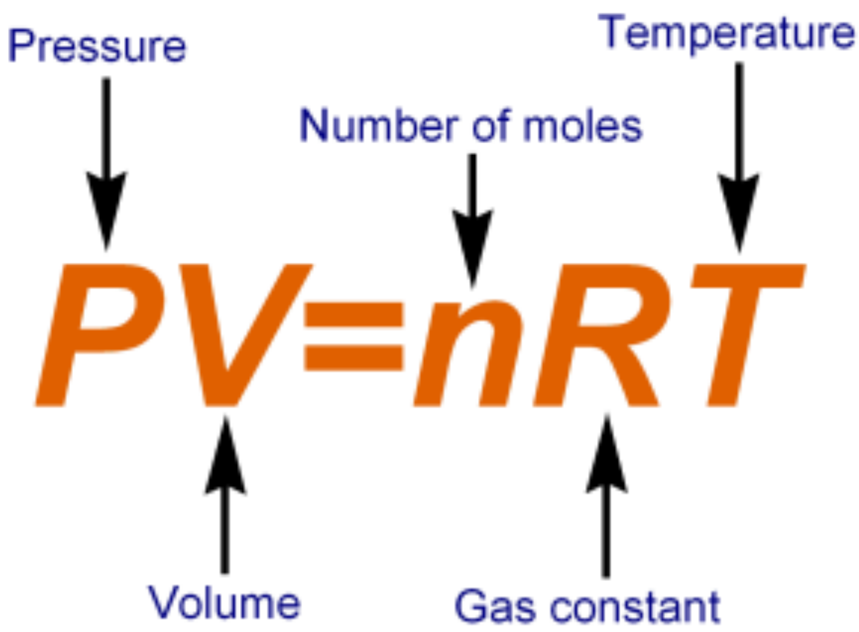


Ideal Gas Law: R constant

- **R constant:**
  - $$\frac{1atm \times 22.4L}{273K} = 0.0821$$
  - $$\frac{101.3kPa \times 22.4L}{273K} = 8.314$$
  - $$\frac{760mmHg \times 22.4L}{273K} = 62.4$$

Ideal Gas Law

- **Ideal Gas Law:**



Sample Problem

- What is the pressure in atm of a 0.108mol sample of He gas at a temperature of 20°C if its volume is 0.505L?

(R = 0.0821atm*L*K^{-1} or
R = 8.314kPa*L*K^{-1} or
R = 62.4mmHg*L*K^{-1})

Sample Problem

- What is the pressure in atm of a 0.108mol sample of He gas at a temperature of 20°C if its volume is 0.505L?
- **ANSWER: 5.14atm**

Sample Problem

- Dentists sometimes use laughing gas (N_2O) to keep patients relaxed during dental procedures. If I have 2.4 moles of laughing gas in a 45L container at 97°C, what is the pressure in kPa?

(R = 0.0821atm*L*K^{-1} or

R = 8.314kPa*L*K^{-1} or

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Sample Problem

- Dentists sometimes use laughing gas (N_2O) to keep patients relaxed during dental procedures. If I have 2.4 moles of laughing gas in a 45L container at 97°C, what is the pressure in kPa?
- **ANSWER: 164.1kPa**

HOMEWORK: Practice problems p. 488 #1, 3, 4, 5, 6